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Requirements for a CMS Shift Management System

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Abstract

Many CMS sub-systems will require continuous operation and monitoring, as will the overall data-taking and shift-related activities of the experiment. A Shift Management System (SMS) is needed to ensure that trained personnel are available at all times to operate CMS in a safe and effective way in order to maximize the physics output of the experiment and to coordinate an equitable sharing of shift-type responsibilities. In this document, we list the principle use cases and requirements and how they impact a proposed design for such a system. The document should be sufficiently detailed that the CMS Commissioning and Technical Coordinators are able to endorse the proposals, and that it becomes the basis for the design for the eventual implementers of the CMS SMS.

Contents

1 Introduction

All aspects of operations for the CMS experiment will involve managing a very large manpower pool, and targeting particular skills to the needed tasks. Given the widely distributed nature of this workforce, and the sheer number of institutions involved, it will be essential to have a Shift Management System (SMS) that provides a set of tools to solicit the availability and skills of individuals, establish shift schedules, and keep an accurate history of each person's contributions. The SMS will be useful not only for activities conducted at CERN, but for any operations activity at remote operations centers, and data processing work at any Tier-N computing center. All information will be maintained in the CMS production database instance and be available any time to all CMS collaborators worldwide through a secure web server.

CMS will eventually operate up to 200 days of the years. During this time, there will be operations personnel responsible for data taking and sub-detectors at the CMS experimental site at SCX (aka Point-5 or P5), data quality monitoring personnel at various locations, persons responsible for data transfer and storage, computing systems support staff, etc. In total, there could be up to 50 people required around-the-clock (24x7) in order to staff CMS operations during some phases of the lifetime of the experiment. Even outside of LHC operation periods, some data taking or safety operations personnel will be required. Managing this scale of enterprise will be greatly facilitated by well-designed and maintained tools in conjunction with dedicated operations managers guaranteeing the effective staffing of the shift operations.

2 Glossary

The purpose of this section is to identify and differentiate the various roles as part of the problem factorization process. Please note we do not infer that single individuals are required for each role, nor that all roles are explicitly filled. These details of these roles should be expanded by the development team in order to understand how each will interact with the system.

2.1 Basic definitions

- ***Shift***. A period of typically eight hours during which one or more operations staff have responsibility for a CMS activity, at SCX or at some similar CMS operations center. During this time, the shift personnel are only responsible for the shift activities.
- ***Shifter***. A single person assigned to perform the responsiblities for a CMS activity for the period of a *shift*.
- ***Shift Crew***. The set of people carrying out the operational responsibilities during a given *shift*. Typically all are present at the same site.
- ***Shift Period***. A date range corresponding to a particular set of CMS operating conditions within which the *shift crew* requirements are largely constant. May be order weeks or a month.
- ***Running Period***. An externally defined data range corresponding to a particular set of LHC operations conditions, typically months or even an LHC year.
- ***Run Period Operations Manager*** (RPOM). One or more senior physicists with responsibility for the overall CMS operations for a complete *running period* or a well-defined large fraction of it. (The RPOM reports to the *Run Coordinator*.
- ***Shift Leader*** (SL). The single person, per site and per *shift*, who is responsible for the overall operations of a given *shift crew*. The SL is a member of the *shift crew*.
- ***SLIMOS***. The Shift Leader In Matters Of Safety. A formal CERN task carried out by one, specifically trained, member of a given *shift crew*.
- ***On-Call Expert***. A person with substantial experience with a particular subsystem who accepts the responsibility to respond to problems any time. The OCE typically carries a wireless device in order to be reached by phone, pager or email.
- ***CMS People Database***. The pool of *shifters* per institution will be automatically retrieved from this database by the *SMS*.
- ***CERN Safety Training Database***. Individual safety training records will be automatically retrieved from this database by the *SMS*.

2.2 System roles

- ***Shift Management System*** (SMS). The database and interfaces for implementing the requirements and use cases in this document.
- ***Shift Management System Developers***. The team of people writing and maintaining the software components of the *SMS*.
- ***Shift System Operator*** (SSO). One or more people responsible for the continuous operation of the *SMS* components, for administrator-level configuration of the *SMS*, for assisting the *RPOMs*, for communication of bugs and feature requests to the *SMS* developers, and for testing new components.
- ***Site Manager***. The person in charge of any facility at which shifts are taken but who does not directly report to the Run Coordinator, e.g. remote operations centers and Tier-N computing facilities.
- ***Sub-System Manager*** (SSM). The person(s) responsible for establishing the *shift* requirements of a particular system (including CMS data taking) for at least a complete *shift period*.

3 Operations Model

While individuals will take shifts and require training and validation to carry out certain responsibilities, each CMS institution leader will take responsibility for the staffing of shifts. CMS will have one or more Shift System Operators (SSO) who will be the human side of the SMS. Under direction of the Run Coordinator and/or RPOM, the SSO will establish the parameters associated to a running period and a set of shifts, and configure the tools used in the SMS.

Each major activity area in CMS will have one or more responsible Sub-System Managers (SSM) who will ensure that shifters have had appropriate training and that their experience is current. The SSM also validates that the shift tasks are carried out and that the task list is kept up to date.

In addition to shift staff working a typical eight hour shift, CMS will also need On-call experts who will be responsible for longer on-call periods of several days or weeks. The scheduling will be the responsibility of the appropriate SSM. The SMS will need to plan for and track this type of activity.

We do not address in this note the actual shift attribution rules that CMS may adopt, neither in terms of sharing between institutions nor shift patterns (all days, all nights, etc.). We assume that a history of shift taking must be maintained and that it may eventually be used for some sort of personal or institutional credit, but we do not consider what form that credit might take.

4 Requirements

The SMS should have a dynamic interface with the CMS people database. There will be a constant flux in the CMS population over the lifetime of the experiment. We will need access to the most accurate and up-to-date information in order to generate shift operations reports for any individual, for any CMS institution and for any time period. The SMS must also maintain the historical information concerning individuals shift activities; individuals may:

- perform many different types of shifts while on CMS;
- change their name, for example due to marital status changes;
- move to another institute;
- work for more than one institute at the same time;
- leave CMS, and possibly return to CMS at a later date.

A web interface would be a natural choice for the SMS. The SMS web client or browser should support any platform (Linux, Windows, Mac) and any browser (Mozilla, Firefox, Internet Explorer, Safari, Opera, Netscape).

The SMS will need access to a simple mail transfer protocol (SMTP) host or server in order to send email shift notifications and reminders. The developers and operators of SMS should take care that non-authorized email (SPAM) does not infiltrate the SMS email system.

The public portal to the SMS might be a web calendar which would support methods to display:

- current shift (per site),
- all shifts per day, week or month (per site), and
- shifts per system per day, week or month (per site).

We may need to consider options to allow open access to the SMS public calendar as part of the CMS outreach program. Alternatively, access may be limited to secure login, for example, SSL protocol (AFS password) or KCA-based (kerberos password). With any format, the information displayed should meet CERN and CMS Institute security and privacy guidelines.

There are at least three levels of authorization, or hierarchy, within SMS: individual users; shift operations managers and SMS system operators.

The individual user will have a one-to-one record match in the CMS people database. Each user can advertise their system preference(s) and their availability or when they cannot be scheduled through the web interface. In

addition, each shifter upon choosing a particular system can be scheduled for shifts, notified by email, and then tracked for system training.

All CMS users who need to take shifts at SCX will need to complete Levels 1, 2, 3 and 4 of the CERN safety training. The SMS will need to access the CERN Safety Training Database to verify that a shifter's training is valid for the assigned shift interval. If the safety training has not been completed or has expired, then the shifter should be warned when they log into the SMS. A shifter may be scheduled conditionally by the SMS (incomplete or expired safety training), as long as the email notification gives mitigating instructions, and the web interface shows some kind of conditional flag (safety training pending).

A sub-system manager (SSM) will be responsible for scheduling the individual shifters for a specific system. Once the SSM assigns an individual to a set of shifts, the individual should not be allowed to modify or cancel the assigned shifts without authorization from the SSM. The SMS should provide a means of communication between the SSM and an individual shifter. The SSM will also be responsible for the On-call experts for the same system.

The SSO will handle the administrator-level configuration of the SMS including the assignments of each SSM to the associated system.

There will be requests to cancel or swap a shift after the schedule has been settled, and all the training for the shifters has been validated or arranged. There will also be exceptional cases of emergencies and "no-shows" which need to be handled on a case by case basis. If there is enough advanced warning, the SSM should be able to find a replacement from the existing pool of trained shifters. If the request is short-notice, possibly two or three days (consider a holiday weekend), the relevant SL and the RPOM should be included in the chain of communication. In the event of a "no-show" or a last-minute emergency cancellation, the SL will need the ability to solicit through the SMS a replacement from the existing pool of trained shifters.

CMS collaborators come from many different experimental backgrounds with sometimes quite different models for shift assignment. Some are used to a strictly voluntary scheduling system, with or without weights assigned to certain shift times; some are used to a more structured shift model where shifts are taken in blocks. In this case some prefer the model of consecutive shifts of a given type (for example five night shifts), while some prefer a model based on a period of one week of shifts with two day shifts, two evening shifts and three night shifts following each other which maximizes the chance that a shifter has seen the most common problems before they come across them in a night shift. It is not possible, or wise, to select a single one of these models at this time. The SMS should be implemented in such a way to adapt to any of these types of shift model. By factorizing the rules and user interface side of the SMS from the database side, this flexibility can be maintained.

5 Possible Sequence of Shift Management Activities

1. Members of the collaboration register with the SMS, or, by default, everyone in the CMS People database can be registered automatically, and their availability for type of shifts and dates will be none by default.

2. Run Coordinators and/or site managers establish the shift periods and the types of activities that should be assigned to shifts. The main data-taking shifts at SCX will be largely influenced by the accelerator schedule. For example, for the running period, the RC may request a CMS Operations crew comprised of a SL, SLIMOS, DAQ Trigger, Beam Conditions, and DQM operators, and a Sub-detector Operations crews from Tracker, Muon, HCAL, ECAL, and Alignment.

3. Sub-System Managers (SSM) establish the roles that need to be filled during all shifts in this period. For example the Tracker SSM may determine that three people are required at SCX, one person at the CCAR, together with two On-Call Experts.

4. Members of the collaboration are solicited to register their availability for shifts of given types in this period. The SMS can send email notification to all registered members. The availability can be general (any shift type for which the person has training) or shift-type specific (Tracker On-call Expert, DAQ shifter). Initially most CMS members will not be qualified for specific tasks, though they may be oriented (by history or by institutional responsibility) towards specific systems, thus the SSM will need to schedule the appropriate training, and record this into the SMS the training levels acquired (with validity intervals). (For that training that is not automatically picked up from the Safety Training database)

5. The SSM establishes the actual shifter - shift assignments according to the actual rules existing at that time. The SSM distributes these assignments to the proposed shifter and their institution leader possibly with a

re-solicitation to the appropriate community (qualified shifters who are not currently scheduled) in case of shortfalls.

6. The shifter actively records the acceptance of the shift assignment by logging into the SMS. (This may be an optional feature that could be turned off by the SSO if deemed too cumbersome by CMS members.)
7. The SL confirms their acceptance of the shift makeup under their leadership by logging into the SMS.
8. The SSO publishes the shift lists, and this publication may contain various statistical analyses such as shifts per person, number of people involved in shifts, shifts per institute, etc. Access to the statistics may be limited to management and/or institutional leaders, or open to anyone who logs into SMS.
9. An SMS cronjob automatically sends email reminders at some agreed period before a shift (or shift period) to each shifter. There may a default setting, or a choice of settings available to each shifter when they log into SMS.
10. The shift takes place. The SMS entries are either validated by the SL, or corrections are logged into the SMS to reflect the actual shifters and the shifts taken.

6 Use Cases

The purpose of this section is to describe some of the use cases in which the users will interact with the SMS.

1. A CMS member may be trained for two or more shift-type systems concurrently, and may have registered their availability in SMS for each system. Does CMS want to disallow or discourage an experienced shifter from taking a duel shift, e.g. Shift Leader and DQM? If it is disallowed, then the SMS can prevent such scheduling. However, an exception may possibly be granted for the combination of a shifter and an On-call expert
2. Many of the CMS members will have to travel to CERN to perform their responsibilities. This will require significant advance scheduling, usually greater than thirty days, and limit their flexibility to certain periods of the year. Although controversial, it may be necessary to have a priority system in SMS which promotes the request of travelers over those who are resident at CERN. There may need to be flag that is not obviously in the CMS people database that a person is or is not resident at CERN in order to implement this feature.
3. If the Shift Leader logs a correction into the SMS, how does this change get made in the appropriate calendars? For example, Joe was scheduled for HCAL, but instead, Marie takes the shift. Does not the SSM for HCAL have to make the change? By making the correction log, an email notification can be sent to the SSM for HCAL, and possibly to all other interested parties (Joe, Marie, institutional leaders...), and we avoid the collision of responsibility, since the SL may not be sufficiently informed about the details of the HCAL training or available shifters.
4. The institutional leader is responsible that the individuals from the institute take the appropriate number, quality and type of shifts. However, the scheduling of shifts is performed by individuals. The institutional leader may supervise the scheduling for the individuals of the institute, and the SMS can include the institutional leader in the communication chain during email notifications, but there is no administrative privilege. The institutional leader will only control the scheduling in the role as an individual shifter.
5. The SMS needs to keep a current record of the institutional leaders. Is this a list that will be maintained manually, or provided by the CMS Management to the SSO (administrator)?
6. SSMs may find it tedious to populate shift schedules from a web interface, particularly when the scheduling follows a well-known pattern of days and times with the only variable being the shifter name. SMS should have a scripting interface with command line options for name, type of shift, date and time, etc. At the minimum, the script should be able to run on lxplus.
7. The SMS will be used at many different locations other than at CERN, and at various time zones. The display of shifts will need to take into account the site location and local time, and preserve visual clarity when multiple site calendars are overlayed. Do we set a standard for day, evening and night shift based on the CERN clock? The time difference between Europe and North America is not constant throughout the year as Daylight Savings Time is recognized differently. There may be CMS institutions from other parts of the world which may take remote monitoring shifts and wish to use the SMS for scheduling as well.

8. For some people, the midnight shift is confusing, as it is not always clear to show up at the beginning of the day, or at the end, even if you place. The best suggestion was to make the start time fifteen minutes prior to the hour, to remove any doubt, i.e. 23:45 P.M.

9. The SL may need access to the contact information of a someone in the CMS people database. Sometimes a shifter overslept, or simply forgot and needs to be reminded to come to the control room. In other cases, the SL may need to find an emergency replacement from a pool of qualified people because the scheduled shifter is in the hospital, stuck on a plane, etc. Perhaps the SL needs to reach an On-call expert for a system, and there is no response to the pager or cell number on the call list. The SMS should have a method to pull up the contact information, maybe even send an automatic email or text message, with the appropriate authorization. If the home phone numbers are available in the CMS people database, we need to determine if we have the privilege to access those records, and the shifters permission to call them when then are scheduled to take shifts.

10. Users should be able to interface their personal calendars (Outlook, iCal) with SMS.

7 SMS Components

(incomplete)

In this section we consider the components of the SMS system. A good decomposition can result in a much more maintainable and evolvable system.

At the core of the SMS is a database. The schema of the database is defined to contain the required data and to implement the relevant links and the immutable rules.

The interaction with the database should be via web-based tools. In this way interaction with the database is only via a defined set of web interfaces. Examples of required interfaces, all of which require some form of secure login:

- For each shifter candidate, an interface to establish their availability, which is a sequence of date-time ranges. Availability can be associated to a number of different shift-types or be generic, subject to eventual training being completed to carry out specific tasks.
- For the SSO, interfaces to establish the shift periods and the shifts required.
- For the SSM and the SL (for a given shift), interfaces to assign or deassign shifters to shifts.
- An interface to list shifts assignments, with the possibility to select for a given shifter name, a date-time range, one or more shift types.
- An interface for statistical information.

These interfaces must implement currently valid rules, which could be changed from time to time. For example, if we adopt a shift-block system, when the SSM assigns someone to a shift on Monday at 08:00, the SMS may fill in a pre-determined pattern of subsequent shifts.

8 Schedule

Table 1 outlines the proposed schedule for the design cycle of the Shift Management System, from preparing the requirements document to the deployment of the SMS for use by the CMS experiment.

9 Acknowledgments

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Table 1: Proposed schedule

Date	Task Description	CMS Assignment
15 May 2007	Review and establishment of requirements	Commissioning Group
30 May 2007	Design and implementation plan for review	Commissioning & Database Groups
30 Jun 2007	Prototyping and development	Database Group
30 Jul 2007	Beta version of schema, service and client for testing	Database Group
30 Aug 2007	Final version available for CMS use	Experiment

A Commercial Systems

The commercial systems are typically designed for small and large businesses which need to track, manage and schedule a labor force. The cost scales with the number of licenses and employees, although some systems other an unlimited license for a fixed price. A commercial system is less flexible than custom software, may be harder to integrate with the CMS people database, and some commercial systems do not provide web interfaces. Most are single platform, Windows-based systems. All commercial systems appear to come with good support and a large number of features, and could be deployed in less time than custom software. Several commercial systems were examined to explore features and potential costs.

- Celayix Software [1]. Celayix provides planning and collaboration tools, and includes a manager-employer online solution. Celayix Web Xpress is based on employee count and the features licensed. Monthly payments start at 544 US per month.
- Visual Staff Scheduler PRO [2]. This online employee scheduling software gives one the ability to schedule the staff from any location. VSS Pro is used by over 70,000 department managers, supervisors and business owners. The cost is based on per user license: 495 US for one license and 9,995 US for one hundred licenses.
- VIP Task Manager Standard Edition Collaboration Groupware Tool [3]. This client/server software is designed for group collaboration and task management by multi-user simultaneous access to a common database through a local area network, and it also alllows users to share, track and report all tasks. VIP Task Manager is designed for Windows XP (Vista capable); there is no Linux version. The cost is based on per user license: 124.95 US for one license and 599.50 US for ten licenses.
- Time Tracker [4]. This employee scheduling software is highly configurable. It has a very flexible display interface, capable of handling even the most complex shift schedules. Time Tracker does not have a web interface; users must access the software from a common network. The cost is 1,095 US for 100 employees and 1,995 US for unlimited employees.

A DZero Experiment Shift Scheduling

The DZero Experiment uses WebCal [5], a web-based calendar program, to manage all control room shift scheduling. Each sub-system is scheduled separately by a Shift Coordinator. The following shifts are staffed by two or three shifters a day:

- Shift Captain (CAP),
- DAQ Shifter (DAQ),
- Silicon Microvertex Tracker Shifter (SMT),
- Central Fiber Tracker Shifter (CFT),
- Calorimeter and Muon Shifter (CALMUO)
- Mechanical Operations Shifter (OPS) and
- Offline Data Transfer and Storage Shifter (SAM).

Additional on-call experts are scheduled on a daily basis for CALMUO, CFT, SMT, Online Controls (CTL), Level-2 Trigger System (L2), Level-3 DAQ System (L3), Central Track Trigger (CTT) and Silicon Track Trigger (STT).

The DZero Shift Calendar [6] is hosted at Michigan State University and is visible to the public. The DZero Shift Calendar is the combination of all sub-systems.

There is administrator control to set preferences and display methods including which shift calendars to combine for "D0 Shifts". Over the history of the experiment, some shifts were merged or dropped all together. For example, the Calorimeter and Muon detector shifts were merged in the summer of 2003, and both the Global Monitoring and Forward Proton Detector (FPD) shifter responsibilities were combined with that of the Shift Captain.

WebCal works reasonably well for scheduling, but it does not provide any method for tracking. Web-scraping scripts were written in Python which would produce shift reports per person, per institute, per quarter and per shift type, and they would be published for the collaboration to review. Since there was no underlying database, some mistakes could be made; the most common was misspelled names in the calendar or in the Python dictionary.

DZero has two extremes for scheduling shifters. The DAQ Shifters [7] have been in a 16-week rotation of "one week on, two weeks off" since September 2002. DZero has a bi-weekly meeting cycle, so the DAQ schedule was designed to give shifters the chance to attend some meetings during their rotation. At each new on-week cycle, the DAQ Shifters will also cycle ahead by eight hours, but they have a full two weeks to shift ahead if they need it. Overall, there is balance in the number of weekdays and weekends as well as evenings and overnight shifts (owls in DZero language). Scheduling DAQ Shifters is simplified because it is in block format. The training is self-sustaining as the mature DAQ Shifters (in the fourth, fifth or sixth week of shifts usually) will train the new batch of shifters.

Scheduling the Shift Captain [8] is more complicated. The position is usually filled by a senior physicist. From a third to a half of the available shifter pool are classified as commuters, which is the DZero term for professors and research scientists that travel into Fermilab for only two to three days at a time. Commuters have a very restricted availability. In addition, many of the Shift Captains have some form of management position, either at their university, at Fermilab or within DZero which affects their schedule. Family obligations are more common constraints as well. In the end, the Shift Captain calendar is filled in piece-meal, and there are always a handful of leftover shifts, usually on weekends, overnights and holidays. The Shift Coordinator must make additional requests, or recruit new Shift Captains.

A L3 Experiment Shift Scheduling

In the following figure we illustrate the shift-cycle system used in L3. Such cycles have the advantage of vastly simplifying the work of the shift managers as entire blocks of shifts are scheduled at one go. This particular structure is however not universally (sic) popular as it results in too rapid changes of working hours; however we believe the principle of block shift allocation has merit and the SMS should be structured so as to allow this type of operation.

References

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[8] http://hep.pa.msu.edu/cgi-bin/webcal/webcal.cgi?function=webmonth&cal=CAP.

	00-08	08-16	16-24
Monday	A7	A1	C4
Tuesday	B6	A2	C5
Wednesday	B7	B1	A3
Thursday	C6	B2	A4
Friday	C7	C1	B3
Saturday	A5	C2	B4
Sunday	A6	C3	B5

In the above table the shifts for a week are shown where three people cover a particular shift type with a pre-determined pattern of shifts. The shifts are taken in the numerical order (So that the shift A7 for example actually takes place on the Monday following the shift A1) The A shifts start their cycle on Monday at 08:00, the B shifts on Wenesday and the C shifts on Friday. The first shift is always on a weekday-day shift

Figure 1: L3 Experiment Shift Pattern.